POSTER: A Framework for IoT Reprogramming

Nian Xue[1,2], Lulu Liang[3], Jie Zhang[1,2], and Xin Huang[1]

[1] Department of Computer Science and Software Engineering,
Xi'an Jiaotong-Liverpool University, Suzhou, China
Nian.Xue15@student.xjtlu.edu.cn, Xin.Huang@xjtlu.edu.cn,
[2] School of Electrical Engineering and Electronics and Computer Science,
University of Liverpool, Liverpool, UK
Jie.Zhang3@liverpool.ac.uk,
[3] China Information Technology Security Evaluation Center
lianglulu@secemail.cn

Abstract. The OpenFlow protocol, as a fundamental element for Software Defined Networking (SDN) architecture, only supports for packet forwarding across switches in general networks. In this paper, the authors propose Software-Defined Function (SDF) which entitles administrators to manage the Internet of Things (IoT) devices and services through abstraction of the underlying infrastructure. The authors further present OpenFunction, a secure communications protocol stemmed from OpenFlow, which enables the IoT devices to be upgraded or reprogrammed remotely and securely. Finally, the authors implement a preliminary SDF system and evaluate its performance. The experimental result demonstrates that the SDF and OpenFunction can grant programmability, flexibility, centralization and security to the IoT.

Key words: OpenFunction; Security; IoT; Software Defined Function

1 Introduction

The recent burgeoning of the Internet of Things (IoT) has been attracting an increasing number of researchers and experts with great attentions due to its significant economic and social values [1]. However, in the wake of the incremental number of the IoT devices, it is more and more difficult to manage and maintain so many devices efficiently [4, 5]. In the meantime, as current IoT devices become considerably intelligent and heterogeneous [6], people thus expect more capabilities and features from these devices. According to [2], there is a tendency that the IoT nodes will receive software updates more frequently due to the growingly dynamic and changeful requirements and services from users and enterprises . Thereupon, how to reprogram or update the remote IoT devices securely and timely is another ongoing challenge.

In order to address the problems mentioned above, this paper proposes Software Defined Function (SDF) that utilizes an SDF controller in the control layer, via a function station situated in the physical infrastructure layer, to reprogram the corresponding IoT end device through OpenFunction protocol derivated from

OpenFlow [3]. In particular, two specific security protocols of OpenFunction are designed to assure the secure communication between an SDF controller and a Function Station. Lastly, a demo system is realized and performance is evaluated in the archetypal SDF system.

2 System Design Overview

In our proposed framework, it comprises three kinds of components: *SDF Controller*, *Function Station* and *IoT Device*. The controller and the function station are usually connected by the Internet or LAN, while the IoT devices are often connected to the function station through short range wireless or wire manners such as WiFi, Bluetooth, Zigbee, serial line and so on. Below is the system design.

- **IoT device.** The IoT devices in our framework are low-price and low-energy ones. They consist of disparate smart entities, for example, temperature sensor, noise sensor, PM 2.5 sensor, etc.
- **Function station.** The function station connects to IoT devices and controller simultaneously in the middle, responsible for upgrading or reprogramming the IoT devices according to the instruction from controller.
- **SDF controller.** The SDF controller plays a pivotal role in the SDF framework, similar to the function of human brain. Since it is able to remotely upgrade or reprogram the functions in IoT devices via function station, it is unnecessary to deployed the controller near those IoT end devices.
- **Protocol I: OpenFunction Authenticated Handshake.** The primary aim is to provide authentication between a controller and function stations. In the first two steps, IDs and nonces are exchanged. Then the function station and the controller negotiate a session key using the pre-distributed public key with a SSL (secure socket layer)-like procedure.
- **Protocol II: OpenFunction Messaging.** It is used to transmit the OpenFunction_reprogramming messages. Messages are encrypted using the session key; and its authenticity is guaranteed with a message authentication code. After the above processes, the function station can reprogramme the IoT device according to the message content. Fig. 1 below shows the whole process.

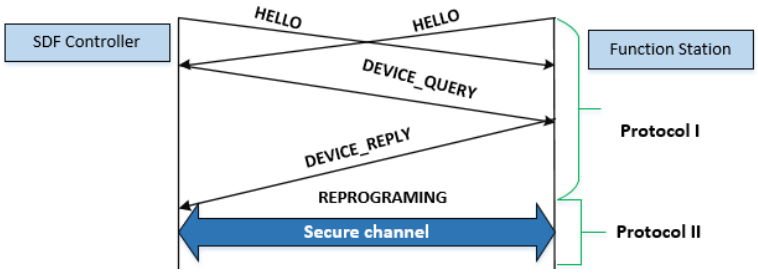
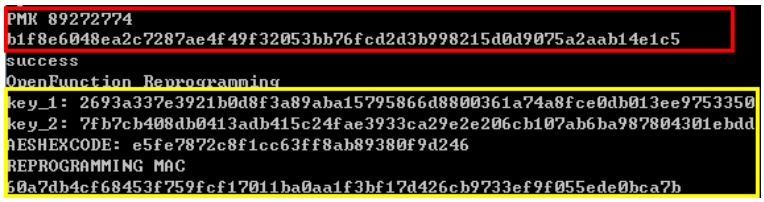


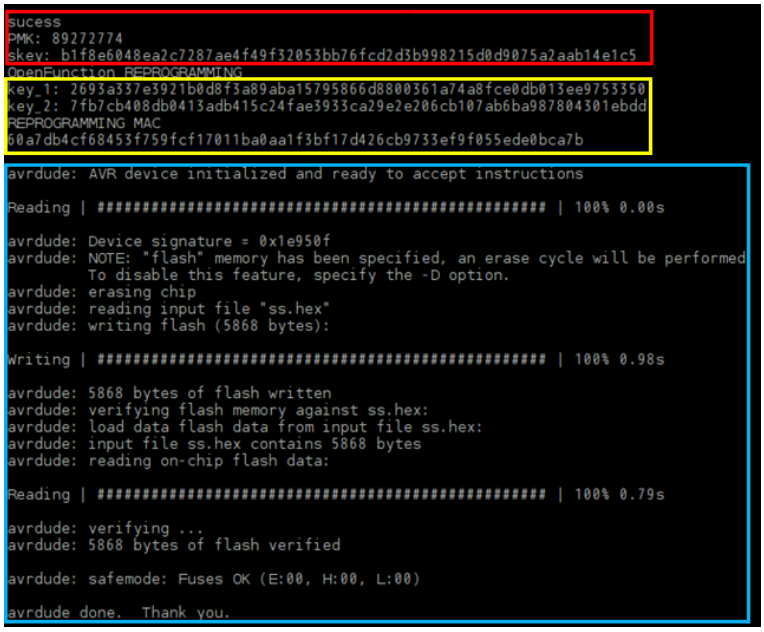
Fig. 1. Process of OpenFunction.

3 Evaluation and Implementation

A function station has stored beforehand a series of functions like a function warehouse. After receiving the update commands from the authenticated controller, the function station will reprogramme the specified smart device through Avrdude, a program used to burn a hexadecimal coding into a firmware. In our experiment, one IoT device was originally preprogrammed as a temperature sensor, as shown in Fig. 3(a). After the experiment, its function is reprogrammed to a smoke sensor. Result of this experiment is illustrated in Fig. 2(a) and Fig. 2(b) and Fig. 3(b). From the figures we can find that the function has been changed. The average runtime for Protocol I is 35.01 ms, and for Protocol II is 31.33 ms.

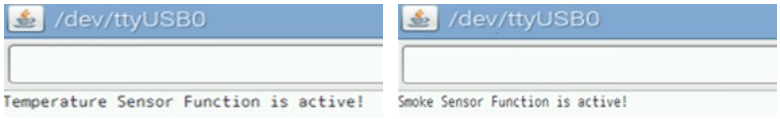


(a) Experiment result on controller



(b) Experiment result on function station

Fig. 2. Implementing Results of OpenFunction



(a) Function before experiment (b) Function after experiment

Fig. 3. Reprogramming results of the IoT device (Arduino)

4 Conclusion

In this paper, we have proposed and implemented SDF, a secure framework for reprogramming IoT devices. Two protocols are designed to guarantee the security during the reprogramming process. Test result indicates OpenFunction can be usded to support IoT devices, as well as obtaining flexibility and security.

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